IMPORTANT NOTICE

Cambridge International Examinations (CIE) in the UK and USA

With effect from the June 2003 examination Cambridge International Examinations will only accept entries in the UK and USA from students registered on courses at CIE registered Centres.

UK and USA private candidates will not be eligible to enter CIE examinations unless they are repatriating from outside the UK/USA and are part way through a course leading to a CIE examination. In that case a letter of support from the Principal of the school which they had attended is required. Other UK and USA private candidates should not embark on courses leading to a CIE examination after June 2003.

This regulation applies only to entry by private candidates in the UK and USA. Entry by private candidates through Centres in other countries is not affected.

Further details are available from Customer Services at Cambridge International Examinations.

Biology

GCE Advanced Subsidiary Level and GCE Advanced Level 9700

(Available in the June and November examinations)

CONTENTS

NOTE

This syllabus has been revised, taking into account comments received from Centres. The balance of topics between the AS and the A2 has been revised, as has the way in which the topics are divided up. A few topics have been deleted. The wording of the learning outcomes has also been clarified to aid teachers' understanding of what is required. Additionally, the Biodiversity Option has been replaced with Mammalian Physiology and the Biotechnology Option has been revised and renamed Microbiology and Biotechnology, ensuring that the Options maintain their relevance in the light of developments in modern biology and industry.

Additional copies of this syllabus and/or the accompanying specimen paper booklet can be ordered from CIE Publications. When ordering, please quote the reference number to be found on the back cover of each of these documents.

INTRODUCTION

This syllabus is designed to give flexibility both to teachers and to candidates and to place emphasis on the understanding and application of scientific concepts and principles as well as on factual material, whilst still giving a thorough introduction to the study of Biology.

Centres and candidates may choose:

- to take all Advanced Level components in the same examination session leading to the full A Level

- to follow a **staged** assessment route to the Advanced Level by taking the Advanced Subsidiary qualification in an earlier examination session. Subject to satisfactory performance such candidates are then only required to take the final part of the assessment (referred to in this syllabus as A2) leading to the full A Level

- to take the Advanced Subsidiary qualification only

AIMS

The syllabus aims to:

1. provide, through well designed studies of experimental and practical biological science, a worthwhile educational experience for all students, whether or not they go on to study Biology beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to:

   become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific import;

   recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life;

   be suitably prepared for studies beyond A Level in biological sciences, in further or higher education, and for professional courses.

2. stimulate students, create and sustain their interest in Biology, and enhance their understanding of its relevance to society.

3. develop abilities and skills that:

   are relevant to the study and practice of biological science;

   are useful in everyday life;

   encourage efficient and safe practice;

   encourage effective communication.

4. develop attitudes relevant to Biology such as:

   concern for accuracy and precision;

   objectivity;

   integrity.

5. assist the development of

   the skills of scientific inquiry;

   initiative;

   inventiveness.

6. stimulate interest in and care for the local and global environment, and understand the need for conservation.

7. promote an awareness:

   that scientific theories and methods have developed, and continue to do so, as a result of co-operative activities of groups and individuals;

   that the study and practice of biological science is subject to social, economic, technological, ethical and cultural influences and limitations;

   that the applications of biological science may be both beneficial and detrimental to the individual, the community and the environment;

   that biological science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal;

   of the importance of the use of IT for communication, as an aid to experiments and as a tool for the interpretation of experimental and theoretical results.

ASSESSMENT OBJECTIVES

These describe the knowledge, skills and abilities that candidates are expected to demonstrate at the end of the course. They reflect those aspects of the aims that will be assessed.

A Knowledge with understanding

Students should be able to demonstrate knowledge and understanding in relation to:

1. biological phenomena, facts, laws, definitions, concepts, theories;
2. biological vocabulary, terminology, conventions (including symbols, quantities and units);
3. scientific instruments and apparatus used in biology, including techniques of operation and aspects of safety;
4. scientific quantities and their determination;
5. biological and technological applications with their social, economic and environmental implications.

The syllabus content defines the factual material that candidates need to recall and explain. Questions testing the objectives above will often begin with one of the following words: *define*, *state*, *name*, *describe*, *explain* or *outline*.

B Handling information and solving problems

Students should be able, using oral, written, symbolic, graphical and numerical forms of presentation, to:

1. locate, select, organise and present information from a variety of sources;
2. translate information from one form to another;
3. manipulate numerical and other data;
4. use information to identify patterns, report trends and draw inferences;
5. present reasoned explanation for phenomena, patterns and relationships;
6. make predictions and propose hypotheses;
7. apply knowledge, including principles, to novel situations;
8. solve problems.

The assessment objectives above cannot be precisely specified in the syllabus content because questions testing such skills are often based on information that is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, deductive manner. Questions testing these objectives may begin with one of the following words: *discuss*, *predict*, *suggest*, *calculate* or *determine*.

C Experimental skills and investigations

Students should be able to:

1. follow a sequence of instructions;
2. use techniques, apparatus and materials;
3. make and record observations, measurements and estimates;
4. interpret and evaluate observations and experimental data;
5. devise and plan investigations, select techniques, apparatus and materials;
6. evaluate methods and techniques, and suggest possible improvements.

SCHEME OF ASSESSMENT

AS candidates are required to enter for Papers 1, 2 and 3.

A2 candidates are required to enter for Papers 4, 5 and 6.

A Level candidates are required to enter for Papers 1, 2, 3, 4, 5 and 6.

Paper	Type of Paper	Duration	Marks	Weighting %	
				AS	A
1	Multiple Choice	1h	40	32	16
2	Structured Questions on AS	1h 15 min	60	48	24
3	Practical Test	1h 15 min	25	20	10
4	Structured Questions based on A2 Core	1h 15 min	60	-	23
5	Practical Test	1h 30 min	30	-	11
6	Options	1h	40	-	16

PAPER 1 (1 h, 40 marks)

This paper will consist of 40 multiple choice questions based on the AS syllabus. All questions will be of the direct choice type with four options.

PAPER 2 (1h 15 min, 60 marks)

This paper will consist of a variable number of structured questions based on the AS syllabus.

PAPER 3 (1 h 15 min, 25 marks)

This paper will be a practical test that is set and marked by CIE. It will include experiments and investigations based on the AS syllabus. Candidates will be expected to show evidence of the following skills in the handling of familiar and unfamiliar biological material:

- planning
- implementing
- interpreting and concluding

Where unfamiliar materials/techniques are required, full instructions will be given. Questions may be set that require the use of a microscope and/or a hand lens.

PAPER 4 (1h 15 min, 60 marks)

This paper will consist of a variable number of structured questions that will carry 45 marks in total. There will also be a free response question, presented in an either/or form, that will carry 15 marks. All questions will be based on the A2 Core syllabus but a knowledge of the AS syllabus may also be required.

PAPER 5 (1 h 30 min, 30 marks)

This paper will be a practical test that is set and marked by CIE. It will include experiments and investigations based on the AS syllabus and the A2 Core syllabus. It will also include questions in which candidates will be expected to design an investigation that may or may not be carried out.

Where unfamiliar materials/techniques are required, full instructions will be given. Questions may be set that require the use of a microscope and/or a hand lens.

Questions involving an understanding of the use of t- and chi-squared tests may be set. The formulae for these tests will be provided.

Although **no** dissection will be set in either Paper 3 or Paper 5, dissection will continue to be a useful aid to teaching e.g. when the heart is being studied. Alternatively, interactive videos or similar may be used, rather than actual dissection of material.

PAPER 6 (1h, 40 marks)

This paper will consist of questions based on each of the Options, but a knowledge of the Core syllabus may also be required.

Candidates will be required to answer questions on ONE option only.
For each Option, there will be a variable number of compulsory, structured questions that will carry 40 marks in total.

Candidates who, having received AS certification, wish to continue their studies to the full Advanced Level qualification may carry their AS marks forward and take just Paper 4, Paper 5 and Paper 6 in the examination session in which they require certification.

RELATIONSHIP BETWEEN THE ASSESSMENT OBJECTIVES AND THE ASSESSMENT COMPONENTS

This is given in the Assessment Grid below.

Assessment Objective	Weighting (%)	Assessment Components
A Knowledge with understanding	45	PAPERS 1, 2, 4, 6
B Handling information and solving problems	30	PAPERS 1, 2, 4, 6
C Experimental skills and investigations	25	PAPERS 3, 5

This gives a general idea of the allocation of marks to assessment objectives A and B in the theory papers. However, the balance on each paper may vary slightly. Fifteen percent of the total marks will be awarded for awareness of the social, economic, environmental and technological implications and applications of Biology. These will be awarded within the 'Knowledge with understanding' and the 'Handling information and solving problems' categories.

Additional Information

Modern Biological Sciences draw extensively on concepts from the physical sciences. It is desirable, therefore, that by the end of the course, candidates should have a knowledge of the following topics, sufficient to aid understanding of biological systems, but **no** questions will be set directly on them.

- The electromagnetic spectrum
- Energy changes (potential energy, activation energy and chemical bond energy)
- Molecules, atoms, ions and electrons
- Acids, bases, pH and buffers
- Isotopes, including radioactive isotopes
- Oxidation and reduction
- Hydrolysis and condensation

Questions set in the examination may involve the basic processes of mathematics for the calculation and use of decimals, means, ratios and percentages.

Candidates may be required to:

(i) construct graphs or present data in other suitable graphical forms,

(ii) calculate rates of processes.

Candidates should be aware of the problems of drawing conclusions from limited data and should appreciate levels of significance, standard deviation and probability and the use of t- and chi-squared tests.

STRUCTURE OF SYLLABUS

The syllabus has been constructed around a common core. The subject content for the Core and the Options syllabuses is presented as learning outcomes. The examination will assess the candidate's knowledge and understanding of these.

A Level candidates are also required to choose **one** Option from the four available.

The Core and Options content is as follows:

1 The Core syllabus –there are sixteen sections.

AS Level candidates will study and be assessed on the first eleven sections, A to K.
A Level candidates will study and be assessed on all sixteen sections, **A** to **P**.

A Cell Structure
B Biological Molecules
C Enzymes
D Cell Membranes and Transport
E Cell and Nuclear Division
F Genetic Control
G Transport
H Gas Exchange
I Infectious Disease
J Immunity
K Ecology
L Energy and Respiration
M Photosynthesis
N Regulation and Control
O Inherited Change and Gene Technology
P Selection and Evolution

2 The Options syllabus – there are four Options.

A Level candidates will study and be assessed on **one** of the following Options.

1 Mammalian Physiology
2 Microbiology and Biotechnology
3 Growth, Development and Reproduction
4 Applications of Genetics

SUBJECT CONTENT

It will be assumed that examples to illustrate concepts and content will be drawn from a wide range of organisms.

It is expected that practical activities will underpin the teaching of the whole syllabus. Asterisks (*) placed alongside learning outcomes indicate areas of the syllabus that present opportunities for practical work.

CORE SYLLABUS

The Core content to be studied by AS candidates, sections A to K, is shown in normal type.

The additional Core content to be studied by A Level candidates, sections **L** to **P**, is shown in **bold** type.

A CELL STRUCTURE

Content

The microscope in cell studies

Cells as the basic units of living organisms

Detailed structure of typical animal and plant cells, as seen under the electron microscope

Outline functions of organelles in plant and animal cells

Characteristics of prokaryotic and eukaryotic cells

Learning Outcomes:

Candidates should be able to:

(a) *use a graticule and stage micrometer to measure cells and be familiar with units (millimetre, micrometre, nanometre) used in cell studies;

(b) explain and distinguish between resolution and magnification, with reference to light microscopy and electron microscopy;

(c) describe and interpret drawings and photographs of typical animal and plant cells, as seen under the electron microscope, recognising the following membrane systems and organelles - rough and smooth endoplasmic reticula, Golgi apparatus, mitochondria, ribosomes, lysosomes, chloroplasts, plasma/cell surface membrane, nuclear envelope, centrioles, nucleus and nucleolus;

(d) outline the functions of the membrane systems and organelles listed in (c);

(e) *compare and contrast the structure of typical animal and plant cells;

(f) *draw plan diagrams of tissues (including a transverse section of a dicotyledonous leaf) and calculate the linear magnification of drawings;

(g) describe the structure of a prokaryotic cell and compare and contrast the structure of prokaryotic cells with eukaryotic cells;

(h) use the knowledge gained in this section in new situations or to solve related problems.

B BIOLOGICAL MOLECULES

Content

The structure of carbohydrates, lipids and proteins and their roles in living organisms

Water and living organisms

Learning Outcomes:

Candidates should be able to:

(a) *carry out tests for reducing and non-reducing sugars (including semi-quantitative use of the Benedict's test), the iodine in potassium iodide solution test for starch, the emulsion test for lipids and the biuret test for proteins;

(b) describe the ring forms of alpha and beta glucose;

(c) describe the formation and breakage of a glycosidic bond;

(d) describe the molecular structure of starch (amylose and amylopectin), glycogen and cellulose and relate these structures to their functions in living organisms;

(e) describe the molecular structure of a triglyceride and a phospholipid and relate these structures to their functions in living organisms;

(f) describe the structure of an amino acid and the formation and breakage of a peptide bond;

(g) explain the meaning of the terms *primary structure*, *secondary structure*, *tertiary structure* and *quaternary structure* of proteins and describe the types of bonding (hydrogen, ionic, disulphide and hydrophobic interactions) that hold the molecule in shape;

(h) describe the molecular structure of haemoglobin as an example of a globular protein, and of collagen as an example of a fibrous protein and relate these structures to their functions (the importance of iron in the haemoglobin molecule should be emphasised);

(i) describe and explain the roles of water in living organisms and as an environment for organisms;

(j) state one role of each of the following inorganic ions in living organisms: calcium, sodium, potassium, magnesium, chloride, nitrate, phosphate;

(k) use the knowledge gained in this section in new situations or to solve related problems.

C ENZYMES

Content

Mode of action of enzymes

Learning Outcomes:

Candidates should be able to:

(a) explain that enzymes are globular proteins that catalyse metabolic reactions;

(b) explain the mode of action of enzymes in terms of an active site, enzyme/substrate complex, lowering of activation energy and enzyme specificity;

(c) *follow the time course of an enzyme-catalysed reaction by measuring rates of formation of products (for example, using catalase) or rates of disappearance of substrate (for example, using amylase);

(d) *investigate and explain the effects of temperature, pH, enzyme concentration and substrate concentration on the rate of enzyme-catalysed reactions, and explain these effects;

(e) explain the effects of competitive and non-competitive inhibitors on the rate of enzyme activity;

(f) use the knowledge gained in this section in new situations or to solve related problems.

D CELL MEMBRANES AND TRANSPORT

Content

The fluid mosaic model of membrane structure

The movement of substances into and out of cells

Learning Outcomes:

Candidates should be able to:

(a) describe and explain the fluid mosaic model of membrane structure, including an outline of the roles of phospholipids, cholesterol, glycolipids, proteins and glycoproteins;

(b) outline the roles of membranes within cells and at the surface of cells;

(c) describe and explain the processes of *diffusion*, *osmosis*, *active transport*, *facilitated diffusion*, *endocytosis* and *exocytosis* (terminology described in the IOB's publication *Biological Nomenclature* should be used; **no** calculations involving water potential will be set);

(d) *investigate the effects on plant cells of immersion in solutions of different water potential;

(e) use the knowledge gained in this section in new situations or to solve related problems.

E CELL AND NUCLEAR DIVISION

Content

Replication and division of nuclei and cells

Understanding of chromosome behaviour in mitosis

Learning Outcomes:

Candidates should be able to:

(a) explain the importance of mitosis in growth, repair and asexual reproduction;

(b) explain the need for the production of genetically identical cells and fine control of replication;

(c) explain how uncontrolled cell division can result in cancer and identify factors that can increase the chances of cancerous growth;

(d) *describe, with the aid of diagrams, the behaviour of chromosomes during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell membrane, centrioles and spindle (names of the main stages are expected);

(e) explain the meanings of the terms *haploid* and *diploid* and the need for a reduction division prior to fertilisation in sexual reproduction;

(f) use the knowledge gained in this section in new situations or to solve related problems.

F GENETIC CONTROL

Content

The structure and replication of DNA

The role of DNA in protein synthesis

Learning Outcomes:

Candidates should be able to:

(a) describe the structure of RNA and DNA and explain the importance of base pairing and hydrogen bonding;

(b) explain how DNA replicates semi-conservatively during interphase;

(c) state that a gene is a sequence of nucleotides as part of a DNA molecule, which codes for a polypeptide;

(d) describe the way in which the nucleotide sequence codes for the amino acid sequence in a polypeptide;

(e) describe how the information on DNA is used to construct polypeptides, including the role of messenger RNA, transfer RNA and the ribosomes;

(f) explain that, as enzymes are proteins, their synthesis is controlled by DNA;

(g) use the knowledge gained in this section in new situations or to solve related problems.

G TRANSPORT

Content

The need for, and functioning of, a transport system in multicellular plants

The need for, and functioning of, a transport system in mammals

The structure and functioning of the mammalian heart

Learning Outcomes:

Candidates should be able to:

(a) explain the need for transport systems in multicellular plants and animals in terms of size and surface area to volume ratios;

(b) define the term *transpiration* and explain that it is an inevitable consequence of gas exchange in plants;

(c) *describe how to investigate experimentally the factors that affect transpiration rate;

(d) *describe the distribution of xylem and phloem tissue in roots, stems and leaves of dicotyledonous plants;

(e) *describe the structure of xylem vessel elements, sieve tube elements and companion cells and be able to recognise these using the light microscope;

(f) relate the structure of xylem vessel elements, sieve tube elements and companion cells to their functions;

(g) explain the movement of water between plant cells and between them and their environment, in terms of water potential (**no** calculations involving water potential will be set);

(h) describe the pathways and explain the mechanisms by which water is transported from soil to xylem and from roots to leaves;

(i) *describe how the leaves of xerophytic plants are adapted to reduce water loss by transpiration;

(j) explain translocation as an energy-requiring process transporting assimilates, especially sucrose, between the leaves (sources) and other parts of the plant (sinks);

(k) explain the translocation of sucrose using the mass flow hypothesis;

(l) *describe the structures of arteries, veins and capillaries and be able to recognise these vessels using the light microscope;

(m) explain the relationship between the structure and function of arteries, veins and capillaries;

(n) *describe the structure of red blood cells, phagocytes and lymphocytes and explain the differences between blood, tissue fluid and lymph;

(o) describe the role of haemoglobin in carrying oxygen and carbon dioxide;

(p) describe and explain the significance of the dissociation curves of adult oxyhaemoglobin at different carbon dioxide levels (the Bohr effect);

(q) describe and explain the significance of the increase in the red blood cell count of humans at high altitude;

(r) describe the external and internal structure of the mammalian heart;

(s) explain the differences in the thickness of the walls of the different chambers in terms of their functions;

(t) describe the mammalian circulatory system as a closed double circulation;

(u) describe the cardiac cycle;

(v) explain how heart action is initiated and controlled (reference should be made to the sinoatrial node, the atrioventricular node and the Purkyne tissue);

(w) use the knowledge gained in this section in new situations or to solve related problems.

H GAS EXCHANGE

Content

The respiratory system

Smoking and smoking-related diseases

Learning Outcomes:

Candidates should be able to:

(a) *describe the structure of the human gas exchange system, including the microscopic structure of the walls of the trachea, bronchioles and alveoli with their associated blood vessels;

(b) *describe the distribution of cartilage, ciliated epithelium, goblet cells and smooth muscle in the trachea, bronchi and bronchioles;

(c) describe the functions of cartilage, cilia, goblet cells, smooth muscle and elastic fibres in the gas exchange system;

(d) describe the process of gas exchange between air in the alveoli and the blood;

(e) explain the terms *tidal volume* and *vital capacity*;

(f) describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system;

(g) describe the signs and symptoms of emphysema, chronic bronchitis and lung cancer;

(h) describe the effects of nicotine and carbon monoxide on the cardiovascular system with reference to atherosclerosis, coronary heart disease and strokes;

(i) evaluate the epidemiological and experimental evidence linking cigarette smoking to disease and early death;

(j) discuss the problems of cardiovascular disease and the ways in which smoking may affect the risk of developing cardiovascular disease;

(k) use the knowledge gained in this section in new situations or to solve related problems.

I INFECTIOUS DISEASE

Content

Cholera, malaria, tuberculosis (TB) and AIDS

Antibiotics

Learning Outcomes:

Candidates should be able to:

(a) explain what is meant by an *infectious disease*;

(b) describe the causes of cholera, malaria, TB and HIV/AIDS;

(c) explain how cholera, malaria, TB and HIV/AIDS are transmitted and assess the importance of these diseases worldwide;

(d) discuss the roles of social, economic and biological factors in the prevention and control of cholera, malaria, TB and HIV/AIDS (a detailed study of the life cycle of the malarial parasite is **not** required);

(e) discuss the global patterns of distribution of malaria and tuberculosis;

(f) outline the role of antibiotics in the treatment of infectious diseases;

(g) use the knowledge gained in this section in new situations or to solve related problems.

J IMMUNITY

Content

The immune system

Vaccination

Learning Outcomes:

Candidates should be able to:

(a) *recognise phagocytes and lymphocytes under the light microscope;

(b) describe the origin, maturation and mode of action of phagocytes;

(c) explain the meaning of the term *immune response*;

(d) distinguish between B- and T-lymphocytes in their mode of action in fighting infection and describe their origin and functions;

(e) explain the role of memory cells in long-term immunity;

(f) relate the molecular structure of antibodies to their functions;

(g) distinguish between *active* and *passive*, *natural* and *artificial immunity* and explain how *vaccination* can control disease;

(h) discuss the reasons why vaccination has eradicated smallpox but not measles, TB, malaria or cholera;

(i) use the knowledge gained in this section in new situations or to solve related problems.

K ECOLOGY

Content

Levels of ecological organisation

Energy flow through ecosystems

Recycling of nitrogen

Learning Outcomes:

Candidates should be able to:

(a) define the terms *habitat*, *niche*, *population*, *community* and *ecosystem* and state examples of each;

(b) explain the terms *producer*, *consumer* and *trophic level* in the context of food chains and food webs;

(c) explain how energy losses occur along food chains and discuss the efficiency of energy transfer between trophic levels;

(d) describe how nitrogen is cycled within an ecosystem, including the roles of microorganisms;

(e) use the knowledge gained in this section in new situations or to solve related problems.

Note: *An ecosystem should be studied in relation to an area familiar to the candidates*.

L ENERGY AND RESPIRATION

Content

The need for energy in living organisms

Respiration as an energy transfer process

Aerobic respiration

Anaerobic respiration

The use of respirometers

Learning Outcomes:

Candidates should be able to:

(a) outline the need for energy in living organisms, as illustrated by anabolic reactions, active transport, movement and the maintenance of body temperature;

(b) describe the structure of ATP as a phosphorylated nucleotide;

(c) describe the universal role of ATP as the energy currency in all living organisms;

(d) explain that the synthesis of ATP is associated with the electron transport chain on the membranes of the mitochondrion;

(e) outline glycolysis as phosphorylation of glucose and the subsequent splitting of hexose phosphate (6C) into two triose phosphate molecules, which are then further oxidised with a small yield of ATP and reduced NAD;

(f) explain that, when oxygen is available, pyruvate is converted into acetyl (2C) coenzyme A, which then combines with oxaloacetate (4C) to form citrate (6C);

(g) outline the Krebs cycle, explaining that citrate is reconverted to oxaloacetate in a series of small steps in the matrix of the mitochondrion (no further details are required);

(h) explain that these processes involve decarboxylation and dehydrogenation and describe the role of NAD;

(i) outline the process of oxidative phosphorylation, including the role of oxygen (no details of the carriers are required);

(j) explain the production of a small yield of ATP from anaerobic respiration and the formation of ethanol in yeast and lactate in mammals, including the concept of oxygen debt;

(k) explain the relative energy values of carbohydrate, lipid and protein as respiratory substrates;

(l) define the term *respiratory quotient* (RQ);

(m) *carry out investigations, using simple respirometers, to measure RQ and the effect of temperature on respiration rate;

(n) use the knowledge gained in this section in new situations or to solve related problems.

M PHOTOSYNTHESIS

Content

Photosynthesis as an energy transfer process

The investigation of limiting factors

Learning Outcomes:

Candidates should be able to:

(a) explain that energy transferred as light is used during photosynthesis to produce complex organic molecules and that the process of respiration allows this energy to be transferred through chemical reactions so that it can be used by living organisms;

(b) describe the photoactivation of chlorophyll resulting in the photolysis of water and in the transfer of energy to ATP and reduced NADP (cyclic and non-cyclic photophosphorylation should be described in outline only);

(c) describe the uses of ATP and reduced NADP in the light-independent stage of photosynthesis;

(d) describe in outline the Calvin cycle involving the light-independent fixation of carbon dioxide by combination with a 5C compound (RuBP) to yield two molecules of a 3C compound GP (PGA), and the conversion of GP into carbohydrates, lipids and amino acids (the regeneration of RuBP should be understood in outline only, and a knowledge of C4 and CAM plants is not required);

(e) *describe the structure of a dicotyledonous leaf, a palisade cell and a chloroplast and relate their structures to their roles in photosynthesis;

(f) *discuss limiting factors in photosynthesis and carry out investigations on the effects of light, carbon dioxide and temperature on the rate of photosynthesis;

(g) use the knowledge gained in this section in new situations or to solve related problems.

N REGULATION AND CONTROL

Content

The importance of homeostasis

Excretion

Control of water and metabolic wastes

Nervous and hormonal communication

Response to changes in the external environment

Regulation of the internal environment

Communication and control in flowering plants

Plant growth regulators

Learning Outcomes:

Candidates should be able to:

(a) discuss the importance of homeostasis in mammals and explain the principles of homeostasis in terms of receptors, effectors and negative feedback;

(b) define the term *excretion* and explain the importance of removing nitrogenous waste products and carbon dioxide from the body;

(c) *describe the gross structure of the kidney and the detailed structure of the nephron with the associated blood vessels (candidates are expected to be able to interpret the histology of the kidney, as seen in sections using the light microscope);

(d) explain the functioning of the kidney in the control of water and metabolic wastes, using water potential terminology;

(e) outline the need for communication systems within mammals to respond to changes in the internal and external environment;

(f) outline the role of sensory receptors in mammals in converting different forms of energy into nerve impulses;

(g) describe the structure of a sensory neurone and a motor neurone and outline their functions in a reflex arc;

(h) describe and explain the transmission of an action potential in a myelinated neurone (the importance of sodium and potassium ions in the impulse transmission should be emphasised);

(i) explain the importance of the myelin sheath (saltatory conduction) and the refractory period in determining the speed of nerve impulse transmission;

(j) describe the structure of a cholinergic synapse and explain how it functions (reference should be made to the role of calcium ions);

(k) outline the roles of synapses in the nervous system in determining the direction of nerve impulse transmission and in allowing the interconnection of nerve pathways;

(l) explain what is meant by the term *endocrine gland*;

(m) *describe the cellular structure of an islet of Langerhans from the pancreas and outline the role of the pancreas as an endocrine gland;

(n) explain how the blood glucose concentration is regulated by negative feedback control mechanisms, with reference to insulin and glucagon;

(o) outline the need for, and the nature of, communication systems within flowering plants to respond to changes in the internal and external environment;

(p) describe the role of auxins in apical dominance;

(q) describe the roles of gibberellins in stem elongation and in the germination of wheat or barley;

(r) describe the role of abscissic acid in the closure of stomata;

(s) use the knowledge gained in this section in new situations or to solve related problems.

O INHERITED CHANGE AND GENE TECHNOLOGY

Content

The passage of information from parent to offspring

The nature of genes and alleles and their role in determining the phenotype

Monohybrid and dihybrid crosses

Recombinant DNA technology

Learning Outcomes:

Candidates should be able to:

(a) *describe, with the aid of diagrams, the behaviour of chromosomes during meiosis, and the associated behaviour of the nuclear envelope, cell membrane and centrioles (names of the main stages are expected, but not the sub-divisions of prophase);

(b) explain how meiosis and fertilisation can lead to variation;

(c) explain the terms *locus*, *allele*, *dominant*, *recessive*, *codominant*, *homozygous*, *heterozygous*, *phenotype* and *genotype*;

(d) use genetic diagrams to solve problems involving monohybrid and dihybrid crosses, including those involving sex linkage, codominance and multiple alleles (but not involving autosomal linkage or epistasis);

(e) use genetic diagrams to solve problems involving test crosses;

(f) use the chi-squared test to test the significance of differences between observed and expected results (the formula for the chi-squared test will be provided);

(g) explain, with examples, how mutation may affect the phenotype;

(h) explain, with examples, how the environment may affect the phenotype;

(i) explain how a change in the nucleotide sequence in DNA may affect the amino acid sequence in a protein and hence the phenotype of the organism;

(j) outline the use of restriction enzymes for removing sections of DNA;

(k) describe the formation of recombinant DNA;

(l) outline the use of recombinant DNA technology in biotechnology, with reference to the synthesis of human insulin by bacteria and production of Factor VIII;

(m) explain the advantages of treating diabetics with human insulin produced by genetic engineering;

(n) describe the benefits and hazards of genetic engineering, with reference to specific examples;

(o) discuss the social and ethical implications of genetic engineering;

(p) use the knowledge gained in this section in new situations or to solve related problems.

P SELECTION AND EVOLUTION

Content

Natural and artificial selection

Learning Outcomes:

Candidates should be able to:

(a) explain how natural selection may bring about evolution;

(b) explain why variation is important in selection;

(c) explain how all organisms can potentially overproduce;

(d) explain, with examples, how environmental factors can act as stabilising or evolutionary forces of natural selection;

(e) describe the processes that affect allele frequencies in populations with reference to the global distribution of malaria and sickle cell anaemia;

(f) explain the role of isolating mechanisms in the evolution of new species;

(g) describe one example of artificial selection;

(h) use the knowledge gained in this section in new situations or to solve related problems.

OPTIONS SYLLABUS

A Level candidates will study and be assessed on **one** of the following Options.

OPTION 1 – MAMMALIAN PHYSIOLOGY

Introduction

This Option is intended to develop:

- an understanding of the principles of heterotrophic nutrition and the processes of digestion and absorption;
- an understanding of the central role of the liver in metabolism;
- an understanding of the locomotory system and the effects of ageing;
- an understanding of the organisation of the nervous system and the effects of malfunction;
- an understanding of the structure and functions of the eye and ear as sense organs.

1 MAMMALIAN NUTRITION

Content

Principles of heterotrophic nutrition

Structure of the human gut and associated organs

Digestion and absorption

Nervous and hormonal control of digestion

Learning Outcomes:

Candidates should be able to:

(a) explain what is meant by and outline the basic principles of *heterotrophic nutrition*;

(b) explain what is meant by the terms *ingestion, digestion, absorption* and *egestion*;

(c) distinguish between mechanical and chemical digestion;

(d) *recognise on photographs and diagrams and by using the light microscope, the following main regions of the gut: stomach, ileum and colon;

(e) describe the structure of the stomach and its functions in digestion and absorption;

(f) describe the structure of the ileum and its functions in digestion and absorption;

(g) describe the functions of the colon in absorption;

(h) *describe the gross structure and histology of the pancreas and explain its functions as an exocrine gland;

(i) state the site of production and action, and explain the functions of pepsin, trypsin, chymotrypsin, exopeptidases, amylases, maltase, lipase and bile salts;

(j) describe the specialisation of teeth and digestive systems in a **named** ruminant and a **named** carnivore;

(k) outline the role of the nervous system and hormones in the control of digestion;

(l) use the knowledge gained in this section in new situations or to solve related problems.

2 THE LIVER

Content

Gross structure and histology

Roles in metabolism

Metabolism of alcohol and the long-term consequences of excessive consumption

Learning Outcomes:

Candidates should be able to:

(a) describe the gross structure of the liver, including its associated blood vessels;

(b) *describe the histology of the liver and recognise this using the light microscope;

(c) explain the roles of the liver in carbohydrate metabolism and the production of glucose from amino acids;

(d) explain the roles of the liver in fat metabolism, including the use of fats in respiration, the synthesis of triglycerides from excess carbohydrate and protein, the synthesis and regulation of cholesterol, and the transport of lipids to and from the liver as lipoproteins (**no** biochemical details are required);

(e) explain the roles of the liver in deamination, transamination and urea formation (an outline of the ornithine cycle is all that is expected);

(f) describe the production and use of bile;

(g) describe the production, and explain the roles, of the plasma proteins fibrinogen, globulins and albumin;

(h) outline the roles of the liver in detoxification;

(i) describe the metabolism of alcohol in the liver and the long-term consequences of excessive alcohol consumption;

(j) use the knowledge gained in this section in new situations or to solve related problems.

3 SUPPORT AND LOCOMOTION

Content

The skeletal system and movement

Histology of bone, cartilage and striated muscle

Muscle contraction

Effects of ageing

Learning Outcomes:

Candidates should be able to:

(a) *identify the major limb bones of a mammal (reference should be made to the structure of the pentadactyl limb);

(b) *relate the structure of a thoracic and a lumbar vertebra to their functions;

(c) describe the lever action of the human arm (the importance of antagonistic muscles in movement should be appreciated);

(d) *use the light microscope to interpret the structure of compact bone and hyaline cartilage;

(e) describe the structure of a synovial joint and identify the different types of joint;

(f) *describe the histology and ultrastructure of striated muscle;

(g) describe the structure of a neuromuscular junction and explain how a nerve impulse causes muscle to contract;

(h) describe the sliding filament theory of muscle contraction (the roles of the control proteins troponin and tropomyosin should be considered);

(i) outline the effects of ageing on the locomotory system with reference to osteoarthritis and osteoporosis;

(j) use the knowledge gained in this section in new situations or to solve related problems.

4 THE NERVOUS SYSTEM

Content

Organisation of the mammalian nervous system

Roles of the autonomic nervous system

Brain structure and function

Alzheimer's disease as an example of brain malfunction

Learning Outcomes:

Candidates should be able to:

(a) describe the organisation of the nervous system with reference to the central and the peripheral systems;

(b) outline the organisation of the autonomic nervous system into a sympathetic and a parasympathetic system;

(c) outline the roles of the autonomic nervous system in controlling the digestive system, heart action and the size of the pupil in the eye;

(d) describe the gross structure of the mammalian brain;

(e) outline the functions of the cerebrum, hypothalamus, cerebellum and medulla oblongata;

(f) describe the symptoms and possible causes of Alzheimer's disease as an example of brain malfunction;

(g) use the knowledge gained in this section in new situations or to solve related problems.

5 SENSE ORGANS AND THE RECEPTION OF STIMULI

Content

Structure and functions of the eye

Effects of ageing on the eye

Structure and functions of the ear

Learning Outcomes:

Candidates should be able to:

(a) describe the gross structure of the eye and outline the functions of its parts, including accommodation;

(b) *describe the structure of the retina, with reference to the arrangement of rods, cones, bipolar cells and ganglion cells;

(c) relate the structure of the eye to visual acuity, colour vision and sensitivity to different light intensities;

(d) outline the general principles involved in the reception and recognition of visual stimuli by the brain;

(e) discuss the effects of ageing on the eye, with reference to cataracts and their treatment;

(f) describe the gross structure of the ear and outline the functions of its parts in hearing and balance;

(g) use the knowledge gained in this section in new situations or to solve related problems.

OPTION 2 – MICROBIOLOGY AND BIOTECHNOLOGY

Introduction

This Option is intended to develop:

- an understanding of the nature of microorganisms;
- an appreciation of the need for safe working practices and specialised laboratory techniques for the preparation, growth, monitoring and control of microorganisms;
- an understanding that biotechnology has a wide range of applications and is a rapidly expanding branch of Biology;
- an appreciation of the economic, social and ethical issues that are raised by applications of biotechnology.

1 MICROBIOLOGY

Content

Features of Viruses, Prokaryotae and Fungi

Structure and life cycle of a bacteriophage and a retrovirus

Structure and asexual reproduction of *Escherichia coli*

Gram staining as a method of the primary identification of bacteria

Structure, asexual reproduction and nutrition of *Penicillium*

Learning Outcomes:

Candidates should be able to:

(a) describe the distinguishing features of Viruses, Prokaryotae and Fungi;

(b) describe the general structure of viruses;

(c) describe the life cycles of the lysogenic bacteriophage, λ, and the Human Immunodeficiency Virus (HIV);

(d) describe the organisation of the genetic material inside bacterial cells and viruses;

(e) describe the structure and asexual reproduction of *Escherichia coli*;

(f) *use the Gram staining technique to identify Gram positive and Gram negative bacteria;

(g) describe the differences in bacterial cell wall structure that are the basis of the Gram staining technique;

(h) describe the structure and asexual reproduction of penicillium and explain its mode of nutrition;

(i) use the knowledge gained in this section in new situations or to solve related problems.

2 TECHNIQUES USED IN MICROBIOLOGY, CELL CULTURE AND GENE BANKING

Content

Scientific and economic reasons for culturing microorganisms and plant cells

In vitro growth requirements of bacteria, fungi and plant cells

Techniques used for the preparation and growth of microorganisms and plant cells

Aseptic techniques

Specialist laboratory requirements

Learning Outcomes:

Candidates should be able to:

(a) outline the techniques of plant tissue culture (e.g. protoplast, explant and pollen culture) and explain its importance (reference should be made to cloning, conservation of endangered species, raising disease-free plants, genetic modification and production of secondary plant products);

(b) describe the *in vitro* growth requirements of bacteria, fungi and plant cells with reference to carbon and nitrogen sources, mineral nutrients, temperature, pH and aeration;

(c) *prepare a nutrient broth and pour nutrient agar plates;

(d) explain the reasons for safe working practices and the need for risk assessments to be made when using microorganisms;

(e) *use aseptic (sterile) techniques to inoculate solid and liquid media (reference should be made to the use of inoculating loops, spreaders and to the stab technique);

(f) *measure bacterial population growth by means of dilution plating and turbidimetry, and use a haemocytometer (a comparison of the techniques and the distinction between viable and total cell counts is expected);

(g) describe the specialist structural features and safety equipment of laboratories working with microorganisms, which are designed to prevent contamination of workers and the environment (reference should be made to the use of negative pressure and air flow hoods);

(h) explain the need to maintain a gene bank for possible future use, including conserving wild types and rare breeds as genetic resources;

(i) describe the maintenance and use of seed banks and of sperm banks;

(j) use the knowledge gained in this section in new situations or to solve related problems.

3 LARGE-SCALE PRODUCTION

Content

Batch and continuous culture of microorganisms

Large-scale production methods

Problems associated with large-scale production

Conditions for fermentation by microorganisms

Learning Outcomes:

Candidates should be able to:

(a) explain what is meant by the terms *batch culture* and *continuous culture* and compare their advantages and disadvantages with reference to the production of penicillin as a secondary metabolite, ethanol, protease enzymes and mycoprotein;

(b) describe the general structural features of a fermenter used for large-scale production;

(c) explain the stages involved and the major problems associated with scaling up laboratory processes to large-scale fermentation processes (reference should be made to the production of penicillin);

(d) *carry out experiments to show the effects of varying conditions on microorganisms (this can be carried out by fermenting glucose or milk in small plastic fizzy drink bottles, or simulation software may be used if fermentation equipment is not available);

(e) use the knowledge gained in this section in new situations or to solve related problems.

4 BIOTECHNOLOGY IN FOOD PRODUCTION

Content

The use of microorganisms and enzymes in food production

Microorganisms as a food source

The production of novel genomes by genetic modification (= GM, genetic engineering, genetic manipulation)

Social, economic, ethical and environmental implications

Learning Outcomes:

Candidates should be able to:

(a) describe and explain the role of biotechnology in the production of cheese, beer, yoghurt and tenderised meat;

(b) describe the use of microorganisms as a food source, with reference to the production of mycoprotein and yeast extract;

(c) describe the production of novel genomes by the isolation of a desired gene from one species of organism, followed by its insertion usually into a different species of host organism (reference should be made to the genetic modification of crop plants);

(d) appreciate the potential social, economic, ethical and environmental implications of biotechnology and genetic modification in (a), (b) and (c) above;

(e) use the knowledge gained in this section in new situations or to solve related problems.

5 BIOTECHNOLOGY IN MEDICINE

Content

The use of biosensors

Monoclonal antibodies and their applications

Proteins of medical importance

The benefits and hazards of genetic engineering

The mode of action of, use of and resistance to an antibiotic

Learning Outcomes:

Candidates should be able to:

(a) explain what is meant by the term *biosensor*;

(b) describe the components of a biosensor and its use with reference to the monitoring of blood glucose;

(c) outline the hybridoma method for the production of a monoclonal antibody;

(d) describe the use of monoclonal antibodies in diagnosis and treatment and in pregnancy testing;

(e) describe the detailed sequence of steps that can be used to produce a protein of medical importance, such as human growth hormone;

(f) explain the reasons for using microorganisms in processes designed for the large-scale production of insulin and human growth hormone;

(g) discuss the benefits and hazards of genetic modification with reference to suitable examples;

(h) describe, for penicillin as an example of an antibiotic, the mode of action on bacteria, use as a chemotheraputic agent in bacterial but not viral infections and causes and effects of antibiotic resistance;

(i) use the knowledge gained in this section in new situations or to solve related problems.

6 BIOTECHNOLOGY IN INDUSTRY AND PUBLIC HEALTH

Content

Immobilised enzymes and their use in industry

Biogas and gasohol

The treatment of domestic and industrial waste

Extraction of heavy metals

Learning Outcomes:

Candidates should be able to:

(a) explain the ways in which enzymes can be immobilised.

(b) explain the advantages of using immobilised enzymes in manufacturing industries;

(c) *carry out an experiment to demonstrate the use of immobilised enzymes, such as amylase immobilised in alginate;

(d) describe the use of **named** microorganisms and substrates in the production of biogas and gasohol;

(e) describe the use of microorganisms for the treatment of domestic sewage and industrial

wastes;

(f) describe the use of microorganisms in the extraction of heavy metals from low grade ores;

(g) use the knowledge gained in this section in new situations or to solve related problems.

OPTION 3 - GROWTH, DEVELOPMENT AND REPRODUCTION

Introduction

This Option is intended to develop:

- an understanding of growth, development and reproduction in a range of organisms;
- an understanding of growth and reproduction in the life cycle of an organism;
- an understanding of methods of investigating and measuring growth;
- an understanding of the role of hormonal control in growth and reproduction.

1 GROWTH AND DEVELOPMENT

Content

Growth is an irreversible increase in mass

Development results in an increase in the complexity of organisms

Learning Outcomes:

Candidates should be able to:

(a) explain how cell division and enlargement lead to growth;

(b) describe the techniques for the measurement of the growth of microorganisms, plants and animals and discuss the problems of measurement;

(c) *measure the growth of a chosen organism, including dry mass assessment;

(d) distinguish between *absolute* and *relative growth rates*;

(e) recognise different types of growth curve and explain patterns of growth;

(f) explain development as a progressive series of changes, including the specialisation of cells;

(g) use the knowledge gained in this section in new situations or to solve related problems.

2 ASEXUAL REPRODUCTION

Content

Natural and artificial means of asexual reproduction in organisms leading to genetic uniformity

Learning Outcomes:

Candidates should be able to:

(a) describe the range of asexual reproduction in organisms using **one** example from each of the five kingdoms: Prokaryotae, Protoctista, Fungi, Plantae, Animalia;

(b) discuss the natural advantages and disadvantages of asexual reproduction and explain its evolutionary consequences;

(c) describe how knowledge of growth and development has been used commercially to develop methods of artificial propagation;

(d) describe the cloning of plants from tissue culture;

(e) discuss the advantages and disadvantages of cloning (reference to the cloning of food plants is expected but **no** practical details of tissue culture are required);

(f) use the knowledge gained in this section in new situations or to solve related problems.

3 SEXUAL REPRODUCTION IN FLOWERING PLANTS

Content

Sexual reproduction requires specialised structures for pollination

Fertilisation produces new genetic combinations

Changes occur after fertilisation leading to the development of the seed and fruit

Learning Outcomes:

Candidates should be able to:

(a) *recognise and name the main parts of a typical, simple flower;

(b) *describe and explain the structural features of a **named**, insect-pollinated and a **named**, wind-pollinated plant;

(c) describe the mechanisms and compare the outcomes of self-pollination and cross-pollination;

(d) *describe anther structure and pollen formation;

(e) *describe ovule development;

(f) describe, and explain the significance of, double fertilisation in the embryo sac;

(g) describe the structural changes that occur after fertilisation leading to the development of the embryo within the seed and the ovary into the fruit;

(h) *investigate embryo development experimentally by using ovules at different stages of development, e.g. shepherd's purse;

(i) *describe seed structure and germination in a **named**, dicotyledonous plant;

(j) use the knowledge gained in this section in new situations or to solve related problems.

4 SEXUAL REPRODUCTION IN HUMANS

Content

Sexual reproduction in humans requires specialised cells

Fusion of gametes produces a zygote

Early development is dependent on maternal resources

Learning Outcomes:

Candidates should be able to:

(a) identify and name the parts of the male and female urinogenital systems;

(b) *recognise and describe the microscopic structure of the ovary and testis (prepared slides from a small mammal may be used);

(c) describe and explain *gametogenesis*;

(d) describe the structures of egg and sperm;

(e) explain how gametogenesis is controlled by hormones;

(f) describe and explain the *menstrual cycle*;

(g) describe the passage of sperm from the testes to the oviduct during sexual intercourse;

(h) state how and where fertilisation occurs;

(i) discuss contraception, *in vitro* fertilisation and abortion from biological and ethical viewpoints;

(j) describe the structure of the placenta;

(k) describe and explain the roles of the placenta and the transport mechanisms involved in placental transfer;

(l) describe the functions of the amnion;

(m) discuss the effect of the actions of the mother on fetal development;

(n) use the knowledge gained in this section in new situations or to solve related problems.

5 CONTROL OF GROWTH AND REPRODUCTION

Content

Growth and development depend on genetic and environmental factors

Plant growth regulators in flowering plants and hormones in mammals form the basis of the control mechanisms

Learning Outcomes:

Candidates should be able to:

(a) explain the factors that control flowering in short-day and long-day plants;

(b) describe the use of plant growth regulators in fruit maturation;

(c) *design and carry out an investigation to identify the major factors affecting germination;

(d) describe the reasons for, and the advantages of, seed dormancy;

(e) explain the interactions of plant growth regulators in the control of seed dormancy;

(f) describe the roles of hormones in the menstrual cycle, pregnancy, birth and lactation;

(g) outline the roles of hormones in pre-menstrual tension, hormone replacement therapy and the menopause;

(h) outline the roles of the hypothalamus and the pituitary gland in human growth and development;

(i) describe the role of thyrotrophin releasing hormone (TRH) from the hypothalamus and thyroid stimulating hormone (TSH) from the pituitary gland in the control of thyroxine secretion;

(j) describe the role of the thyroid gland and the functions of thyroxine;

(k) use the knowledge gained in this section in new situations or to solve related problems.

OPTION 4 - APPLICATIONS OF GENETICS

This Option is intended to develop:

- an understanding of the causes of variation;
- an understanding of the principles and uses of selective breeding;
- an understanding of the importance of genetic diversity;
- an understanding of the ways in which organisms can be modified by genetic engineering;
- an understanding of some aspects of human genetics and an appreciation of their medical, ethical and social implications.

1 VARIATION

Content

Mutations

The effect of genotype and environment on phenotype

Interaction between loci

Linkage and crossing-over

Learning Outcomes:

Candidates should be able to:

(a) explain, with examples, what is meant by the terms *gene mutation* and *chromosome mutation*;

(b) describe the difference between *continuous* and *discontinuous variation*;

(c) explain the genetic basis of continuous and discontinuous variation by reference to the number of genes that control the characteristic;

(d) recognise that both genotype and environment contribute to phenotypic variance ($V_P = V_G + V_E$) (**no** calculations of heritability will be expected);

(e) describe **two** examples of the effect of the environment on the phenotype;

(f) describe interaction at **one** locus (dominance and codominance);

(g) describe gene interaction between loci (epistasis);

(h) predict phenotypic ratios in problems involving epistasis;

(i) explain the meaning of the terms *linkage* and *crossing-over*;

(j) explain the effect of linkage and crossing-over on the phenotypic ratios from dihybrid crosses;

(k) use the chi-squared test to test the significance of differences between observed and expected results (the formula for the chi-squared test will be provided);

(l) use the knowledge gained in this section in new situations or to solve related problems.

2 SELECTIVE BREEDING

Content

The selection of desirable characteristics of organisms by selective breeding

Progeny testing

Artificial insemination

Embryo transplantation

Social and ethical implications of these techniques

Learning Outcomes:

Candidates should be able to:

(a) outline the principle of selective breeding and explain why selective breeding is carried out;

(b) explain, with practical details, how the process of selective breeding may be carried out in **one named** plant example and **one named** animal example;

(c) compare selective breeding with the evolutionary process;

(d) explain the use of progeny testing;

(e) discuss the advantages, disadvantages and use of artificial insemination (AI);

(f) describe the use of, and the techniques used in, embryo transplantation;

(g) discuss the ethical implications of the use of AI, *in vitro* fertilisation and embryo transplantation in animals and their social and ethical implications in humans;

(h) use the knowledge gained in this section in new situations or to solve related problems.

3 GENETIC DIVERSITY

Content

The problems of inbreeding

The need to maintain genetic resources

The development of resistance

Learning Outcomes:

Candidates should be able to:

(a) describe the harmful effects of inbreeding;

(b) explain the need to maintain a gene bank for possible future use, including conserving wild types and rare breeds as genetic resources;

(c) describe the maintenance and use of seed banks and sperm banks;

(d) describe the process of cloning plants from tissue culture;

(e) describe the genetic basis of resistance in prokaryotes and in eukaryotes;

(f) explain, with specific examples, how selective breeding is used to produce disease-resistant varieties in plants and animals;

(g) describe the evolution of antibiotic resistance in bacteria and pesticide resistance in insects, and discuss the implications of the evolution of such resistance;

(h) use the knowledge gained in this section in new situations or to solve related problems.

4 HUMAN GENETICS

Content

Genetic disorders in humans

Genetic screening and genetic counselling

Gene therapy, its possible benefits and hazards

Genetic fingerprinting and its uses

The significance of genetic constitution for tissue compatibility in transplant surgery

Learning Outcomes:

Candidates should be able to:

(a) describe cystic fibrosis, Huntington's disease (chorea) and Down's syndrome in humans, and explain how they are inherited (issues related to these genetic conditions may need to be handled with sensitivity);

(b) describe how genetic screening is carried out;

(c) discuss the advantages and disadvantages of genetic screening and the need for genetic counselling;

(d) explain the theoretical basis of gene therapy and discuss its possible benefits and hazards;

(e) explain the theoretical basis of genetic fingerprinting and outline how it is carried out;

(f) explain the significance of genetic compatibility in transplant surgery, with reference to ABO blood groups and the major histocompatibility (HLA) system;

(g) use the knowledge gained in this section in new situations or to solve related problems.

RESOURCE LIST

Teachers may find reference to the following books helpful. These titles represent some of the texts available at the time of printing this syllabus. Teachers are encouraged to choose texts for class use which they feel will be of interest to their students and will support their own teaching style. Texts asterisked (*) indicate those more suitable when choice or availability is limited, and which are most suitable for use as a main text by students.

CORE SYLLABUS

Alma, P J *(1993) Environmental Concerns*
(CUP, www.cambridge.org) ISBN 0521428696

Boyle, M and Senior, K *(2002) Biology,* Collins Advanced Science
(Collins Educational, www.collinseducation.com) ISBN 0007136005

Cadogan, A and Best, G *(1992) Environment and Ecology*, Biology Advanced Studies
(Nelson Thornes, www.nelsonthornes.com) ISBN 0174482159

Carr, M and Cordell, R *(1993) Biochemistry*, Biology Advanced Studies
(Nelson Thornes, www.nelsonthornes.com) ISBN 0174481969

*Chapman, J L and Reiss, M J *(1998) Ecology Principles and Applications* (2nd ed)
(CUP, www.cambridge.org) ISBN 0521588022

Clegg, C J and Mackean, D G *(2000) Advanced Biology: Principles and Applications* (2nd ed)
(John Murray, www.johnmurray.co.uk) ISBN 0719576709

Clegg, C J, Mackean, D G, Reynolds, R and Openshaw, P *(1996) Advanced biology study guide*
(John Murray, www.johnmurray.co.uk) ISBN 071955358X

*Jones, M, Fosbery, R and Taylor, D *(2000) Biology 1* Cambridge Advanced Sciences
(CUP, www.cambridge.org) ISBN 052178719X

*Jones, M and Gregory, J *(2001) Biology 2* Cambridge Advanced Sciences
(CUP, www.cambridge.org) ISBN 0521797144

*Jones, M and Jones, G *(1997) Advanced Biology*
(CUP, www.cambridge.org) ISBN 0521484731

Kent, M *(2000) Advanced Biology*
(Oxford University Press, www.oup.co.uk) ISBN 0199141959

King, T J, Reiss, M and Roberts, M *(2001) Practical Advanced Biology*
(Nelson Thornes, www.nelsonthornes.com) ISBN 0174483082

Marieb, E *(2001) Human Anatomy and Physiology* (5th ed)
(Benjamin Cummings, www.aw.com) ISBN 0805349898

Phillips, W D and Chilton, T J *(1994) A-Level Biology* (revised ed)
(Oxford University Press, www.oup.co.uk) ISBN 0199145849

*Roberts, M, Monger, G and Reiss, M *(2000) Advanced Biology*
(Nelson Thornes, www.nelsonthornes.com) ISBN 0174387326

Rowland, M *(1992) Biology* Bath Advanced Science
(Nelson Thornes, www.nelsonthornes.com) ISBN 0174384254

Siddiqui, S A *(1999) Comprehensive Practical Biology for A Levels*
(Ferozsons, Lahore) ISBN 9690015729

*Taylor, D J, Green, N P O, Stout, G W and Soper, R *(1997) Biological Science 1 and 2* (3rd ed)
(CUP, www.cambridge.org) ISBN 0521561787

*Taylor, D *(1989) Human Physical Health* Cambridge Social Biology Topics
(CUP, www.cambridge.org) ISBN 0521313066

The following may also be useful:

Biological Sciences Review
(Philip Allan Updates, www.philipallan.co.uk)

Stewart, A (*1995-6*) *Lab notes: your up-to-date guide to research in genetics*
(Wellcome Centre for Medical Science, http://library.wellcome.ac.uk)

OPTIONS SYLLABUS

Option 1 – Mammalian Physiology

Clegg, C J and Mackean, D G (*2000*) *Advanced Biology: Principles and Applications* (2nd ed)
(John Murray, www.johnmurray.co.uk) ISBN 0719576709

Jones, M and Jones, G (*1997*) *Advanced Biology*
(CUP, www.cambridge.org) ISBN 0521484731

*Jones, M and Jones, G (*2002*) *Mammalian Physiology and Behaviour* Cambridge Advanced Sciences (CUP, www.cambridge.org) ISBN 0521797497

Phillips, W D and Chilton, T J (*1994*) *A-Level Biology* (revised ed)
(Oxford University Press, www.oup.co.uk) ISBN 0199145849

Taylor, D J, Green, N P O, Stout, G W and Soper, R (*1997*) *Biological Science 1 and 2* (3rd ed)
(CUP, www.cambridge.org) ISBN 0521651787

Option 2 – Microbiology and Biotechnology

Taylor, J (*2001*) *Microorganisms and Biotechnology* (2nd ed) Bath Advanced Science
(Nelson Thornes, www.nelsonthornes.com) ISBN 0174482558

*Lowrie, P and Wells, S (*2000*) *Microbiology and Biotechnology* (2nd ed) Cambridge Advanced Sciences (CUP, www.cambridge.org) ISBN 0521787238

Option 3 – Growth, Development and Reproduction

Austin, C R and Short, R V (eds) (*1984*) *Hormonal Control of Reproduction*
(CUP, www.cambridge.org) ISBN 0521275946

Avery, R, Cuthill, I, Miller, R and Rowlands, G (*1994*) *The Five Kingdoms* Biology Advanced Studies (Nelson Thornes, www.nelsonthornes.com) ISBN 0174482299

Baggott, L M (1997) *Human Reproduction* Cambridge Social Biology Topics
(CUP, www.cambridge.org) ISBN 0521469147

*Taylor, D (*2001*) *Growth, Development and Reproduction* (2nd ed) Cambridge Advanced Sciences
(CUP, www.cambridge.org) ISBN 0521787211

Option 4 – Applications of Genetics

Calladine, C and Drew, H (*1997*) *Understanding DNA* (2nd ed)
(Academic Press, www.apcatalog.com) ISBN 0121550885

Dyson, T (*1994*) *The Ethics of in Vitro Fertilization*
(Continuum International Publishing – Mowbray) ISBN 0264672836

*Gregory, J (*2000*) *Applications of Genetics* (2nd ed) Cambridge Advanced Sciences
(CUP, www.cambridge.org) ISBN 0521787254

Hayward, G (*1992*) *Applied Genetics* Bath Advanced Science
(Nelson Thornes, www.nelsonthornes.com) ISBN 0174385110

Nicholl, D S T (*2002*) *An Introduction to Genetic Engineering* (2nd ed) Studies in Biology
(CUP, www.cambridge.org) ISBN 0521004713

Vardy, P (*1999*) *The Puzzle of Ethics*
(Fount) ISBN 0006281443

LABORATORY EQUIPMENT

The following is a list of basic materials and apparatus which would be found in a well-equipped Biology laboratory. However, the list is by no means exhaustive.

In accordance with the COSHH (Control of Substances Hazardous to Health) Regulations, operative in the UK, a hazard appraisal of the list has been carried out.

The following codes are used where relevant.

C = corrosive substance

F = highly flammable substance

H = harmful or irritating substance

O = oxidising substance

T = toxic substance

General

Test-tubes and boiling tubes (heat resistant)
Test-tube holders or similar means of holding tubes
Test-tube racks or similar in which to stand tubes
Bungs to fit test-tubes/boiling tubes
Specimen tubes with corks
A means of heating - Bunsen burners or similar
Thermometers
Measuring cylinders
Means of measuring small volumes, e.g. syringes (various sizes)
Teat pipettes
Beakers
Tripod stands and gauzes
Filter funnels and filter paper
Petri dishes (plastic) or similar small containers
White tiles or other suitable surface on which to cut
Glass slides and coverslips
Conical flasks
Clamp (retort) stands and bosses
Visking (dialysis) tubing
Capillary tubing
Soda glass tubing
Paper towelling or tissue
Cotton wool
Solid glass rods
Black paper/aluminium foil
Means of writing on glassware (water resistant markers)
Hand lenses (not less than x6, preferably x8)
Forceps
Scissors
Mounted needles
Cutting implement, e.g. solid-edged razor blade/knife/scalpel
Mortars and pestles
Safety spectacles
Microscope and lamp/inbuilt illumination with high and low power objective lenses (1 each or 1 between 2)

Eyepiece graticules and stage micrometers
Bench lamp with flexible arm
Balance (to 0.1 g)
Water-baths or equivalent
Cork borers
Stopclock/timer showing seconds
Simple respirometer - can be 'homemade'
Pipe cleaners/other suitable aid to demonstrate mitosis and meiosis
Apparatus to measure rate and depth of breathing

Stocks of:
Iodine in potassium iodide solution
Benedict's solution
[**C**] - Biuret reagent/potassium hydroxide and copper sulphate solution
[**F**] - Ethanol (for fats test)
[**F**] - Methylated spirit (extraction of chlorophyll)
Sucrose (use AR for non-reducing sugar test)
Glucose
Starch
[**C**] - Potassium hydroxide
Sodium chloride
Dilute hydrochloric acid
Hydrogencarbonate indicator
Sodium bicarbonate/sodium hydrogencarbonate
Limewater
Distilled/deionised water
Universal Indicator paper and chart
Litmus paper
Eosin/red ink
Methylene blue
Vaseline/petroleum jelly (or similar)
DCPIP (dichlorophenol-indophenol)
Ascorbic acid (vitamin C)
[**H**] – Enzymes: amylase, trypsin (or bacterial protease)
Potatoes (store in fridge) or mung beans (to germinate for use) as a source of catalase
Non-competitive enzyme inhibitor (e.g. copper sulphate)
Stains for preparing slides to show mitosis - e.g. carmine acetic
[**H**] - Feulgen stain (Schiff's reagent)
Apparatus/chemicals for water cultures to show effect of N, P, K on growth

Apparatus for sampling animals
Beating tray ('homemade')
Pooter ('homemade')
Sweeping net (muslin)
Plankton net and dip net (if aquatic environment is being sampled)
Pitfall trap/jam jar; suitable cover to prevent water entry
Trays for hand sorting

Slides of :
Mitosis and meiosis
Animal and plant cells
Arteries/veins/capillaries
Blood smear
Trachea and lungs
Kidney
Ts stem, ts root and ts leaf of a xerophyte (e.g. *Erica* or *Psamma* or local equivalent)
Ts spinal cord

Additional equipment for the Options

Option 1
Thoracic and lumbar vertebrae

Slides of:
Pancreas
Liver
Striated muscle
Eye (including retina)

Option 2
Petri dishes, culture bottles, autoclave
Nutrient broth, nutrient agar
Inoculating wires/bioloops
Haemocytometers
Tape for sealing dishes
Cultures of live yoghurt
Appropriate cultures of microorganisms, e.g. *Escherichia coli, Bacillus subtilis*
Gram staining solutions: crystal violet and safranin
Appropriate disinfectants
Materials for preparing immobilised enzymes: calcium chloride, sodium alginate

Option 3

Slides of:
Ovary and testis
Anther and ovule

Option 4

No special equipment is needed.

NOTES ON THE USE OF STATISTICS IN BIOLOGY (A LEVEL ONLY)

Candidates should know how to apply a t-test and a chi-squared test. t-tests are of value in much of Biology, while the chi-squared test allows the evaluation of the results of breeding experiments and ecological sampling. Each of these tests is dealt with fully in many books on statistics for Biology.

Candidates are **not** expected to remember the following equations **nor** to remember for what the symbols stand. They are expected to be able to use the equations to calculate standard deviations, to test for significant differences between the means of two small, unpaired samples and to perform a chi-squared test on suitable data from genetics or ecology. Candidates will be given access to the equations, the meaning of the symbols, a t-table and a chi-squared table.

standard deviation $s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$

t-test $t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$ $v = n_1 + n_2 - 2$

χ^2 test $\chi^2 = \sum \frac{(O - E)^2}{E}$ $v = c - 1$

Key to symbols

- s = standard deviation
- $\bar{x}$ = mean
- c = number of classes
- $\sum$ = 'sum of …'
- n = sample size (number of observations)
- O = observed 'value'
- x = observation
- v = degrees of freedom
- E = expected 'value'

Candidates should note that on some calculators the symbol σ may appear instead of the symbol s.

Candidates are **not** expected to be familiar with the term standard error, **nor** to appreciate the difference between s_n (σ_n) and s_{n-1} (σ_{n-1}). Candidates should have a brief understanding of what is meant by the term 'normal distribution' and appreciate levels of significance. (Tables will be provided by CIE.)

Questions involving the use of a t-test or a chi-squared test may be set on Paper 6. Questions involving an **understanding** of the use of the tests may be set on Paper 5, but detailed computation will **not** be required.

Electronic calculators will be allowed in the examination, subject to the CIE general regulations.

GLOSSARY OF TERMS USED IN BIOLOGY PAPERS

It is hoped that the glossary (which is relevant only to Biology) will prove helpful to candidates as a guide, i.e. it is neither exhaustive nor definitive. The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context.

1. *Define* (the term(s)…) is intended literally, only a formal statement or equivalent paraphrase being required.
2. *What do you understand by/What is meant by* (the term(s)…) normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
3. *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can readily be obtained 'by inspection'.
4. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified, this should **not** be exceeded.

5 (a) *Explain* may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to give reasons for. The candidate needs to leave the examiner in no doubt **why** something happens.

(b) *Give a reason/Give reasons* is another way of asking candidates to explain **why** something happens.

6 (a) *Describe*, the data or information given in a graph, table or diagram, requires the candidate to state the key points that can be seen in the stimulus material. Where possible, reference should be made to numbers drawn from the stimulus material.

(b) *Describe*, a process, requires the candidate to give a step by step written statement of what happens during the process.

Describe and *explain* may be coupled, as may *state* and *explain*.

7. *Discuss* requires the candidate to give a critical account of the points involved in the topic.
8. *Outline* implies brevity, i.e. restricting the answer to giving essentials.
9. *Predict* implies that the candidate is **not** expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.

   Predict also implies a concise answer, with no supporting statement required.
10. *Deduce* is used in a similar way to *predict* except that some supporting statement is required, e.g. reference to a law or principle, or the necessary reasoning is to be included in the answer.
11. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in Chemistry, two or more substances may satisfy the given conditions describing an 'unknown'), or to imply that candidates are expected to apply their general knowledge to a 'novel' situation, one that may be formally 'not in the syllabus'.
12. *Find* is a general term that may variously be interpreted as *calculate, measure, determine, etc.*
13. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved. Suitable units should be given where possible.
14. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or mass, using a balance. Suitable units should be given where possible.
15. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, e.g. the Young modulus, relative molecular mass.

16. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.

17. *Sketch,* when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, *but* candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value.

    In diagrams, *sketch* implies that a simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.

18. *Compare* requires candidates to provide both the similarities and differences between things or concepts.

19. *Recognise* is often used to identify facts, characteristics or concepts that are critical (relevant/appropriate) to the understanding of a situation, event, process or phenomenon.

20. *Classify* requires candidates to group things based on common characteristics.

In all questions, the number of marks allocated are shown on the examination paper and should be used as a guide by candidates to how much detail to give. In describing a process the mark allocation should guide the candidate about how many steps to include. In explaining why something happens, it guides you how many reasons to give, or how much detail to give for each reason.